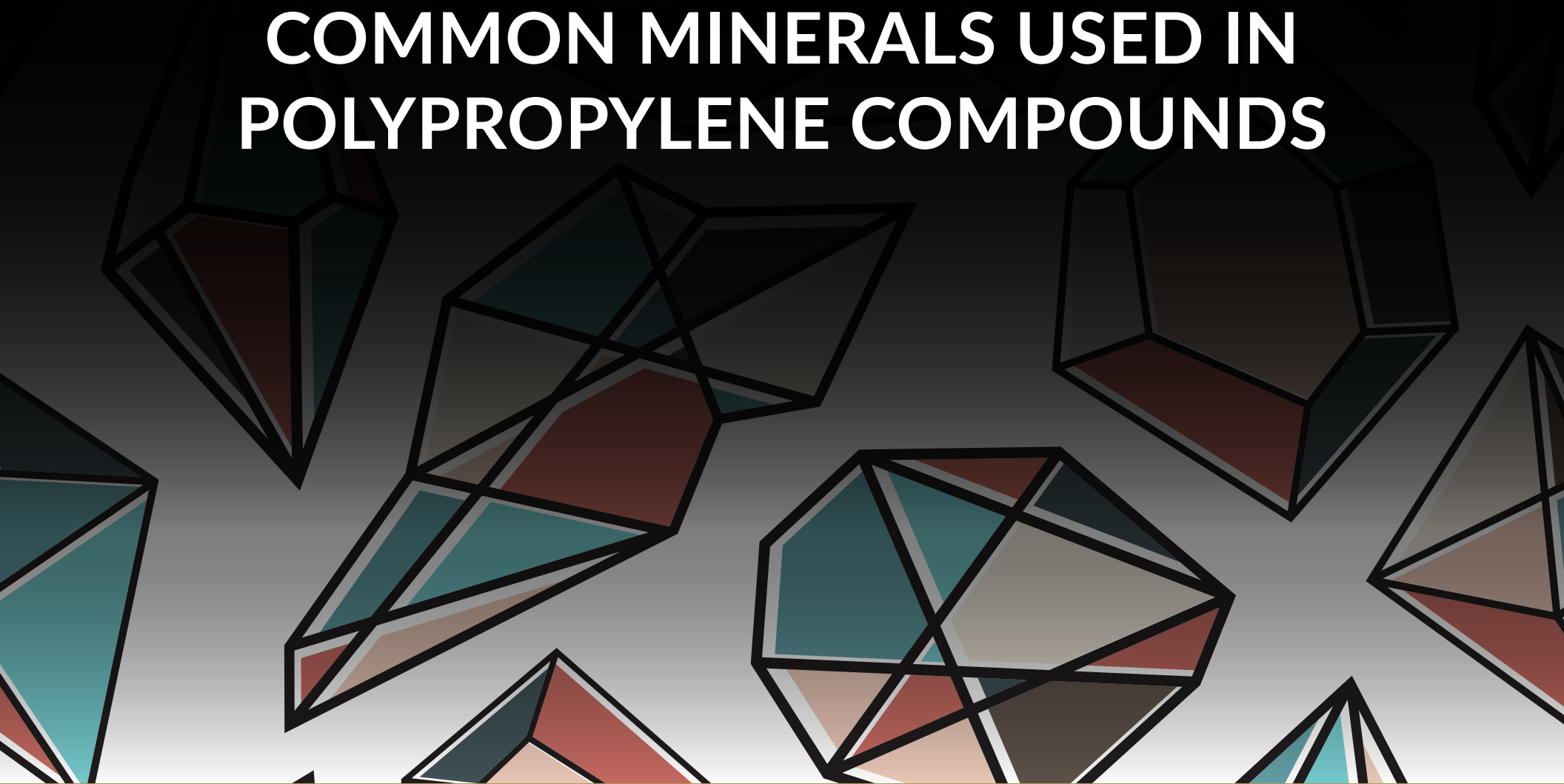




# COMMON MINERALS USED IN POLYPROPYLENE COMPOUNDS



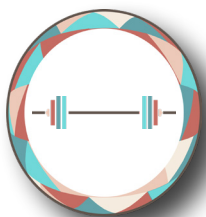
Minerals are commonly added to polypropylene compounds to modify various physical and mechanical properties. Properties that can be modified include:

- Modulus
- Tensile or Flex Strength
- Creep Resistance
- HDT
- Impact
- Gloss
- Density
- Abrasion Resistance
- Shrinkage and Warpage
- X-Ray Shielding
- Hardness
- Lubricity
- Flammability
- Other

Depending on the specific mineral and the loading level used, they may be considered to be either a filler, a reinforcement or a modifier.



Minerals would be considered to be a filler if they reduce the cost of the compound but do not provide any significant improvement in properties.



They would be considered to be a reinforcement if they improve the strength or stiffness of the compound.



And finally they would be considered to be a modifier if they change properties such as X-ray shielding or flame resistance.

Important properties of minerals include their particle size, shape and aspect ratio. Properties of common minerals used in polypropylene can be found in Table 1.



**TABLE 1: PROPERTIES OF COMMON MINERALS USED IN POLYPROPYLENE COMPOUNDS**

MINERAL FILLER	DENSITY (g/cm <sup>3</sup> )	HARDNESS (Mohs)	SHAPE	ASPECT RATIO	AVERAGE SIZE (microns)
Calcium Carbonate	2.7	3 – 4	Blocky	1 – 3	0.02 – 30
Talc	2.7 – 2.8	1	Plate	5 – 40	0.5 – 20
Mica	2.8 – 2.9	2.5 – 4	Plate	20 – 100	5 – 1000
Kaolin	2.6	2	Plate	10 – 30	10 – 30
Wollastonite	2.9	4.5	Fiber	5 – 30	1 – 500
Barium Sulfate	4 – 4.5	3 – 3.5	Round	1	0.1 – 30

In addition to these common minerals, there are a number of other minerals that are also used in polypropylene compounds. These include, but are not limited to: silica, quartz, dolomite, alumina trihydrate, magnesium hydroxide, iron oxide, hematite, magnetite, halloysite, titanium dioxide, zinc oxide and diatomaceous earth. Of these minerals, magnesium hydroxide is used as a flame retardant while titanium dioxide and zinc oxide are used as white pigments.

The selection of which mineral to use in a polypropylene compound will depend on the desired properties of the final compound. Table 2 gives a property comparison of polypropylene homopolymer with 40% loading of different minerals.



**TABLE 2: PROPERTY COMPARISON OF PP HOMOPOLYMER WITH DIFFERENT MINERALS**

MINERAL FILLER	TENSILE STRENGTH (psi)	FLEX MODULUS (psi)	NOTCHED IZOD (ft-lb/in)
Calcium Carbonate, 40%	3400	320,000	0.7
Talc, 40%	4600	400,000	0.5
Mica, 40%	4400	750,000	0.9
Kaolin, 40%	3500	180,000	1.4
Wollastonite, 40%	2900	390,000	1.5
Barium Sulfate, 50%	3500	290,000	0.9



## CALCIUM CARBONATE

Calcium carbonate is used because of its low cost and high whiteness. It also offers a balance of stiffness, dart impact, good surface appearance, heat aging performance, good colorability and resistance to environmental stress cracking.



## TALC

Talc is used to improve tensile strength, flex modulus and heat deflection temperature. Talc is one of the softest, least abrasive minerals.



## MICA

Mica is used where color is not so important but where maximum tensile strength, flex modulus and heat deflection temperature are desired. Mica is also used in applications requiring sound-deadening properties, reduced warpage and lower coefficient of thermal expansion. Muscovite mica is whiter in color than phlogopite mica which is amber to brown in color.



## KAOLIN

Kaolin is used in applications where impact properties and electrical properties are the most important characteristics.



## WOLLASTONITE

Wollastonite is used in applications requiring high tensile strength, flex modulus, heat deflection temperature and impact. Wollastonite gives a good surface appearance and can also improve the scratch resistance of polypropylene compounds.



## BARIUM SULFATE

Barium sulfate is used in applications requiring high density and sound deadening properties. It is also used in applications where X-ray shielding is required.

Table 3 shows mineral selection based on the desired tensile strength, flex modulus, notched Izod, HDT or warpage of the final polypropylene compound.



**TABLE 3: MINERAL SELECTION TABLE**

POOR
FAIR
GOOD
BEST

MINERAL FILLER	TENSILE STRENGTH	FLEX MODULUS	NOTCHED IZOD IMPACT	HDT	WARPAGE
Calcium Carbonate	GOOD	FAIR	GOOD	POOR	LOW
Talc	BEST	GOOD	POOR	BEST	LOW
Mica	BEST	BEST	POOR	BEST	LOW
Kaolin	GOOD	POOR	BEST	POOR	LOW
Wollastonite	FAIR	GOOD	GOOD	GOOD	MODERATE
Barium Sulfate	GOOD	FAIR	FAIR	FAIR	LOW

As mentioned earlier, **PARTICLE SIZE, SHAPE** and **ASPECT RATIO** are critical to the overall performance of the mineral. Particle size is often defined by the 'average' particle size. However, what may be more important are the 10% smallest particles and 10% largest particles. If the particle size is too small, they tend to increase viscosity and cause agglomeration. If the particle size is too large, it will act as a flaw and lower the impact and elongation properties. Particle size greater than about 20 microns will tend to act like a flaw and reduce impact. This is one reason why adding mica to a compound results in low impact performance.

Particle shape will also affect the properties of the final compound. Higher aspect ratio particles, like wollastonite, will tend to be better reinforcing agents than round or platy particles. Platy particles like talc and mica can also act as reinforcements, especially if they have high aspect ratios. Platy particles can reinforce along both of their plate dimensions, unlike fibers or acicular minerals which only reinforce along their one primary dimension. Round, low aspect ratio particles, like calcium carbonate, really don't offer any reinforcement. However, they do help reduce warpage because they affect all 3-dimensions equally.

In order to be a good reinforcement, the mineral should have a high aspect ratio. This is why mica, talc and wollastonite make good reinforcing minerals. However, the tradeoff is that high aspect ratios will typically reduce impact. This is because one of the mineral dimensions will likely be over the 20-micron size limit where it becomes a stress concentrator. So why do some of the minerals with high aspect ratios still give us better-than-expected impact in our final molded parts? Because the aspect ratio in the final compound is smaller due to breakage of the mineral that occurs during compounding and molding. This results in a final aspect ratio that is lower than the original which results in improved impact. However, reducing the final aspect ratio will also negatively affect its performance as a reinforcing agent.

In summary, there are a variety of minerals that can be added to modify the physical and mechanical properties of polypropylene compounds. The choice of which mineral, or which combination of minerals, to use will depend on cost, colorability, density, processability or other characteristic.